

CLAIMS

5 The claims defining the invention are as follows:

1. A method of electromagnetically designing a shaped-reflector multibeam antenna, said method comprising the steps of:

10 providing an initial configuration of reflectors shaped with an initial reflector shaping process and feeds for said multibeam antenna for required beam directions, said reflector shaping process being an iterative optimization process for increasing the focusing of optical rays incident on said multibeam antenna from each of said beam directions;

15 optimizing radiation patterns of said feeds, said optimizing being an iterative process for satisfying required upper and lower bounds for gain radiation patterns of beams of said multibeam antenna; and

optimizing surface shapes and sizes of said reflectors, said optimizing being an iterative process for satisfying said required upper and lower bounds for said gain radiation patterns of said beams of said multibeam antenna.

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2. The method according to claim 1, wherein said reflectors are a pair, one reflector being a primary or main reflector illuminated by another reflector being a subreflector, which is illuminated by said feeds.

25 3. The method according to claim 1, wherein each feed comprises a radiating element or a radiating element combined with one or more reflectors or lenses.

4. The method according to claim 1, wherein said providing step comprises the steps of:

30 determining requirements for said beam directions and gain radiation patterns; specifying said reflectors and applying said initial reflector-shaping process; specifying said feeds having a nominal design;

placing feeds at focal points; and
calculating gain radiation patterns of beams of said multibeam antenna, said
calculating using the methods of physical optics or the geometrical or physical
theories of diffraction.

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5. The method according to claim 1, wherein said optimizing step for said
radiation patterns of said feeds comprises shaping of said radiation patterns of said feeds
to decrease spillover of said beams at one or more of said reflectors of said multibeam
antenna.

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6. The method according to claim 1, wherein said optimizing step for radiation
patterns of feeds comprises shaping said radiation patterns of said feeds to compensate
for distorting effects of said reflectors on shapes of said beams or to increase rotational
symmetry of said beams at one or more reflectors of said multibeam antenna.

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7. The method according to claim 1, wherein said optimizing step for said surface
shapes and sizes of said reflectors comprises optimizing said reflectors to increase
rotational symmetry or decrease spillover of said beams at one or more of said reflectors
of said multibeam antenna.

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8. The method according to claim 1, wherein said optimizing steps comprise
representing the sizes or shapes of said feeds or said reflectors in terms of a set of
variable parameters and optimizing one or more of these parameters.

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9. The method according to claim 8, wherein said optimizing steps involve
performing a gradient search for said parameters that minimize a weighted sum of gain
radiation pattern errors in regard to required upper and lower bounds for said gain
radiation patterns of said beams of said multibeam antenna.

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10. The method according to claim 8, wherein said optimizing steps involve
minimizing the sizes of said reflectors or said feeds whilst satisfying said requirements
for said gain radiation patterns of said multibeam antenna.

11. The method according to claim 8, wherein said optimizing step for said radiation patterns of said feeds comprises the steps of:

- parameterizing a profile of a horn feed; and
- 5 applying a gradient search to minimize a maximum gain of a respective feed radiation pattern for off-axis angles exceeding a pre-determined value.

12. The method according to claim 1, wherein said two optimizing steps are performed in one or more iterations to satisfy said requirements for said gain patterns of
10 said multibeam antenna.

13. The method according to claim 1, wherein said optimizing steps comprise calculating said gain radiation patterns of said beams of said multibeam antenna, the said calculating using the methods of physical optics or the geometrical or physical theories of
15 diffraction.

14. An apparatus for electromagnetically designing a shaped-reflector multibeam antenna, said apparatus comprising:

means providing an initial configuration of reflectors shaped with an initial
20 reflector shaping process and feeds for said multibeam antenna for required beam directions, said reflector shaping process being an iterative optimization process for increasing the focusing of optical rays incident on said multibeam antenna from each of said beam directions;

means for optimizing said radiation patterns of said feeds, said optimizing being
25 an iterative process for satisfying required upper and lower bounds for gain radiation patterns of beams of said multibeam antenna; and

means for optimizing surface shapes and sizes of said reflectors, said optimizing being an iterative process for satisfying said required upper and lower bounds for said gain radiation patterns of said beams of said multibeam antenna.

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15. The apparatus according to claim 14, wherein said reflectors are a pair, one reflector being a primary or main reflector illuminated by another reflector being a subreflector, which is illuminated by said feeds.

5 16. The apparatus according to claim 14, wherein each feed comprises a radiating element or a radiating element combined with one or more reflectors or lenses.

17. The apparatus according to claim 14, wherein said providing means comprises:

10 means for determining requirements for said beam directions and gain radiation patterns;

 means for specifying said reflectors and applying said initial reflector-shaping process;

 means for specifying said feeds having a nominal design;

15 means for placing feeds at focal points; and

 means for calculating gain radiation patterns of beams of said multibeam antenna, said calculating means using the methods of physical optics or the geometrical or physical theories of diffraction.

20 18. The apparatus according to claim 14, wherein said optimizing means for said radiation patterns of said feeds comprises means for shaping of said radiation patterns of said feeds to decrease spillover of said beams at one or more of said reflectors of said multibeam antenna.

25 19. The apparatus according to claim 14, wherein said optimizing step for radiation patterns of feeds comprises shaping said radiation patterns of said feeds to compensate for distorting effects of said reflectors on shapes of said beams or to increase rotational symmetry of said beams at one or more reflectors of said multibeam antenna.

30 20. The apparatus according to claim 14, wherein said optimizing means for said surface shapes and sizes of said reflectors comprises means for optimizing said reflectors

to increase rotational symmetry or decrease spillover of said beams at one or more of said reflectors of said multibeam antenna.

21. The apparatus according to claim 14, wherein said two optimizing means each
5 comprise means for representing the sizes or shapes of said feeds or said reflectors in terms of a set of variable parameters and optimizing one or more of these parameters.

22. The apparatus according to claim 21, wherein said two optimizing means
involve performing a gradient search for said parameters that minimize a weighted sum
10 of gain radiation pattern errors in regard to required upper and lower bounds for gain radiation patterns of beams of said multibeam antenna.

23. The apparatus according to claim 21, wherein said two optimizing means
involve minimizing the sizes of said reflectors or said feeds whilst satisfying said
15 requirements for gain radiation patterns of said multibeam antenna.

24. The apparatus according to claim 21, wherein said optimizing means for
radiation patterns of feeds comprises:
means for parameterizing a profile of a horn feed; and
20 means for applying a gradient search to minimize a maximum gain of a respective feed radiation pattern for off-axis angles exceeding a pre-determined value.

25. The apparatus according to claim 14, wherein said optimizing means operate
in one or more iterations to satisfy said requirements for gain patterns of said multibeam
25 antenna.

26. The apparatus according to claim 14, wherein said two optimizing means each
comprise means for calculating the said gain radiation patterns of the beams of said
multibeam antenna, said calculating means using the methods of physical optics or the
30 geometrical or physical theories of diffraction.

27. A computer program product having a computer readable medium having a computer program recorded therein for designing a shaped-reflector multibeam antenna, said computer program product comprising

5 computer program code means of providing an initial configuration of reflectors shaped with an initial reflector shaping process and feeds for said multibeam antenna for required beam directions, said reflector shaping process being an iterative optimization process for increasing the focusing of optical rays incident on said multibeam antenna from each of said beam directions;

10 computer program code means for optimizing radiation pattern of said feeds, said optimizing being an iterative process for satisfying required upper and lower bounds for gain radiation patterns of beams of said multibeam antenna; and

15 computer program code means for optimizing the surface shapes and sizes of said reflectors, said optimizing being an iterative process for satisfying said required upper and lower bounds for said gain radiation patterns of said beams of said multibeam antenna.

28. The computer program product according to claim 27, wherein said reflectors are a pair, one reflector being a primary or main reflector illuminated by another reflector being a subreflector, which is illuminated by said feeds.

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29. The computer program product according to claim 27, wherein each feed comprises a radiating element or a radiating element combined with one or more reflectors or lenses.

25 30. The computer program product according to claim 27, wherein said computer program code means for providing comprises:

computer program code means for determining requirements for said beam directions and gain radiation patterns;

30 computer program code means for specifying said reflectors and applying said initial reflector-shaping process;

computer program code means for specifying said feeds having a nominal design; computer program code means for placing feeds at focal points; and

computer program code means for calculating gain radiation patterns of beams of said multibeam antenna, said computer program code means for calculating using the methods of physical optics or the geometrical or physical theories of diffraction.

5 31. The computer program product according to claim 27, wherein said computer program code means for optimizing said radiation patterns of said feeds comprises computer program code means for shaping of said radiation patterns of said feeds to decrease spillover of said beams at one or more of said reflectors of said multibeam antenna.

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 32. The computer program product according to claim 27, wherein said computer program code means for optimizing said radiation patterns of said feeds comprises computer program code means for shaping said radiation patterns of said feeds to compensate for distorting effects of said reflectors on shapes of said beams or to increase
15 rotational symmetry of said beams at one or more reflectors of said multibeam antenna.

 33. The computer program product according to claim 27, wherein said computer program code means for optimizing said surface shapes and sizes of said reflectors comprises computer program code means for optimizing said reflectors to increase
20 rotational symmetry or decrease spillover of said beams at one or more of said reflectors of said multibeam antenna.

 34. The computer program product according to claim 27, wherein said computer program code means for optimizing comprises computer program code means for
25 representing said sizes or shapes of said feeds or said reflectors in terms of a set of variable parameters and optimizing one or more of these parameters.

 35. The computer program product according to claim 34, wherein said computer program code means for optimizing involves performing a gradient search for said
30 parameters that minimize a weighted sum of gain radiation pattern errors in regard to said required upper and lower bounds for said gain radiation patterns of said beams of said multibeam antenna.

36. The computer program product according to claim 34, wherein said computer program code means for optimizing involves minimizing said sizes of said reflectors or said feeds whilst satisfying said requirements for said gain radiation patterns of said
5 multibeam antenna.

37. The computer program product according to claim 34, wherein said computer program code means for optimizing said radiation patterns of said feeds comprises:
computer program code means of parameterizing a profile of a horn feed; and
10 computer program code means for applying a gradient search to minimize a maximum gain of a respective feed radiation pattern for off-axis angles exceeding a pre-determined value.

38. The computer program product according to claim 27, wherein said computer
15 program code means for optimizing perform one or more iterations to satisfy said requirements for gain patterns of said multibeam antenna.

39. The computer program product according to claim 27, wherein said computer program code means for optimizing comprises computer program code means for
20 calculating the said gain radiation patterns of the beams of said multibeam antenna, said computer program code means for calculating using the methods of physical optics or the geometrical or physical theories of diffraction.

40. An apparatus for electromagnetically designing a shaped-reflector multibeam
25 antenna, said apparatus comprising:
a storage unit for storing data and computer program code to be carried out by a processing unit;
a processing unit coupled to said storage unit, said processing unit being programmed with said computer program code to:
30 provide an initial configuration of reflectors shaped with an initial reflector shaping process and feeds for said multibeam antenna for required beam directions, said reflector shaping process being an iterative optimization process for increasing the

focusing of optical rays incident on said multibeam antenna from each of said beam directions;

optimize said radiation patterns of said feeds, said optimizing being an iterative process for satisfying required upper and lower bounds for gain radiation patterns of beams of said multibeam antenna; and

optimize surface shapes and sizes of said reflectors, said optimizing being an iterative process for satisfying said required upper and lower bounds for said gain radiation patterns of said beams of said multibeam antenna.

41. The apparatus according to claim 40, wherein said reflectors are a pair, one reflector being a primary or main reflector illuminated by another reflector being a subreflector, which is illuminated by said feeds.

42. The apparatus according to claim 40, wherein each feed comprises a radiating element or a radiating element combined with one or more reflectors or lenses.

43. The apparatus according to claim 40, wherein said processing unit is programmed to:

- determine requirements for said beam directions and gain radiation patterns;
- specify said reflectors and apply said initial reflector-shaping process;
- specify said feeds having a nominal design;
- place feeds at focal points; and
- calculate gain radiation patterns of beams of said multibeam antenna, said calculating using the methods of physical optics or the geometrical or physical theories of diffraction.

44. The apparatus according to claim 40, wherein optimizing said radiation patterns of said feeds comprises shaping of said radiation patterns of said feeds to decrease spillover of said beams at one or more of said reflectors of said multibeam antenna.

45. The apparatus according to claim 40, wherein optimizing radiation patterns of feeds comprises shaping said radiation patterns of said feeds to compensate for distorting effects of said reflectors on shapes of said beams or to increase rotational symmetry of said beams at one or more reflectors of said multibeam antenna.

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46. The apparatus according to claim 40, wherein optimizing said surface shapes and sizes of said reflectors comprises optimizing said reflectors to increase rotational symmetry or decrease spillover of said beams at one or more of said reflectors of said multibeam antenna.

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